RCP scenario description

Among them, RCP2.6 indicates that the radiative forcing level will reach 3.1 W/m² by the mid-century and then decline to 2.6 W/m² by the year 2100.In the three climate scenarios of the 2020-2049 RCP, the frequency of heavy rainfall events (total daily rainfall exceeding 50 mm) will be higher, increasing from 1-3 days per year in 2020-2030 to 2040-2049.RCP4.5 is the medium-term future emission scenario, indicating that the peak scenario will be reached in about 2040, and the total radiation intensity may reach 4.5 W/m^2, but it will remain stable thereafter, RCP8.5 is an extreme carbon emission scenario, and its GHG emissions will continue to increase throughout the 21st century. Since the daily potential evapotranspiration data is not provided under the RCP scenarios, it can be estimated by daily average temperature (Ta, ℃) and incident solar radiation (Rs, MJ·m^{-2}·day^{-1}) [49]:

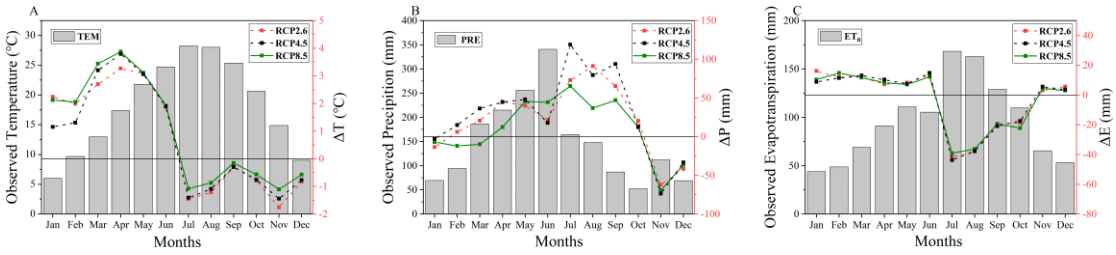
$$\mathbf{ET_0 = -0.611 + 0.149}\boldsymbol{R_s} \mathbf{+ 0.079}\boldsymbol{Ta}.$$

The ET0 term was first proposed by the Food and Agriculture Organization (FAO) to represent evapotranspiration from a defined vegetated surface [50].

We calculated the historical annual mean values for temperature, precipitation, and evaporation from 2006 to 2018, along with the mean temperature and precipitation output under three RCP climate scenarios. The evaporation data were derived using the SI method. The Delta value for temperature was determined by subtracting the historical average temperature from the future average temperature. The Delta for precipitation was calculated as (future average precipitation / historical average precipitation - 1) × 100%. The method for calculating evaporation was similar to that for precipitation. The results of these calculations are presented in the following table:

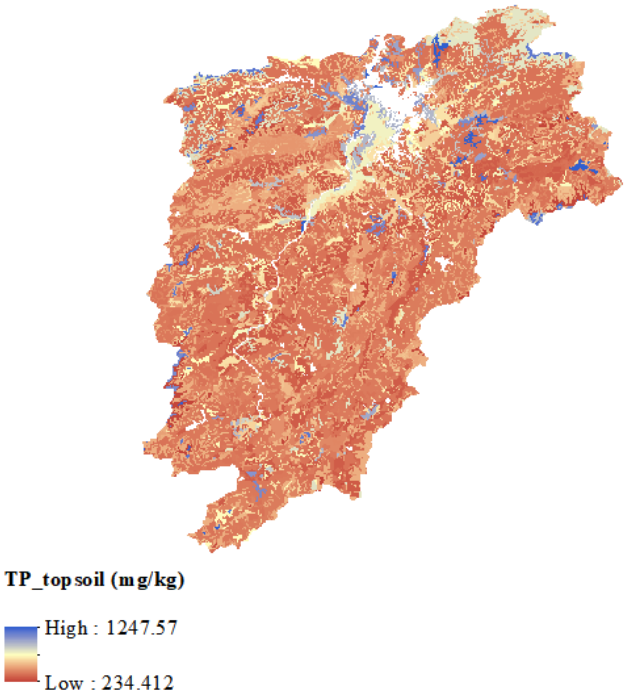
Supplementary Table S1 The historical annual mean temperature, precipitation and evaporation from 2006 to 2018 were 18.3℃, 1794 mm yr-1 and 1157 mm yr-1 respectively in Poyang Lake Basin. The annual mean temperature, precipitation and evaporation under three RCP scenarios were compared with historical observations.

Scenario	ΔT (℃)	ΔP (%)	ΔE (%)
RCP2.6	+0.74℃	+15.0%	-3.40%
RCP4.5	+0.72℃	+20.0%	-3.90%
RCP8.5	+1.01℃	+7.2%	-3.90%

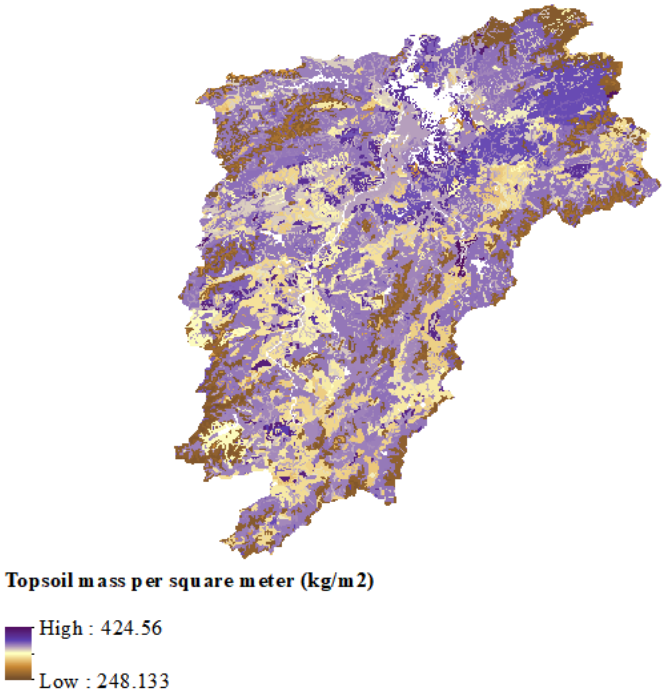


Supplementary Figure S1 Monthly means of the changes in temperature (A),

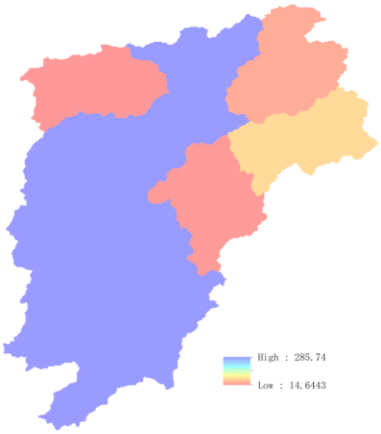
precipitation (B) and evaporation (C) under three climate change scenarios (RCP2.6, RCP4.5, RCP8.5) during 2020-2049 relative to the historical monthly mean temperature, precipitation and evaporation from 2006 to 2018 (grey vertical bars).



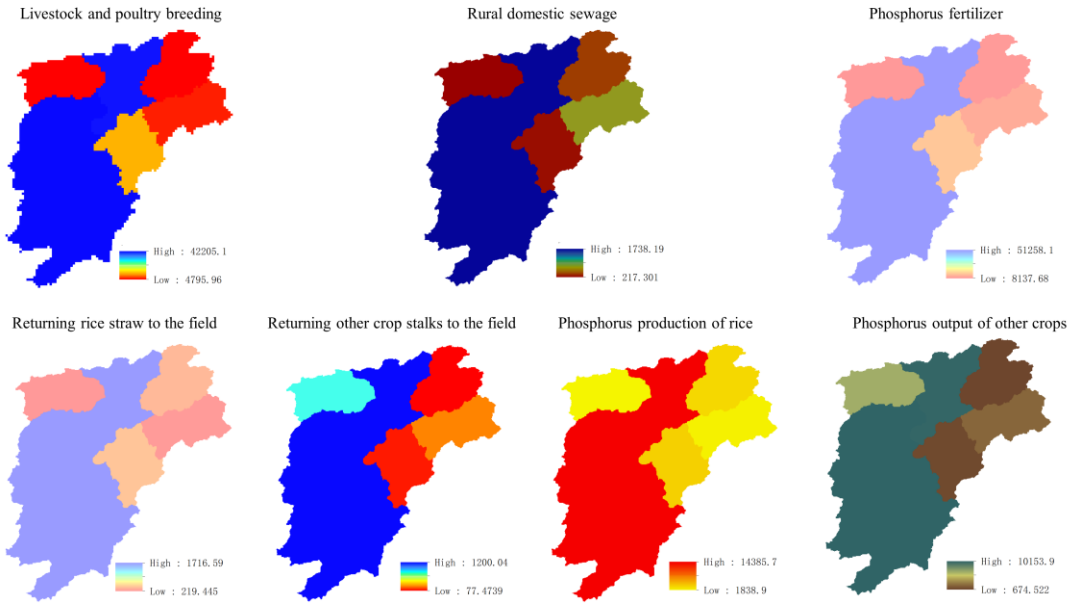
Supplementary Figure S2. Initial soil TP concentrations in Poyang Lake Basin.



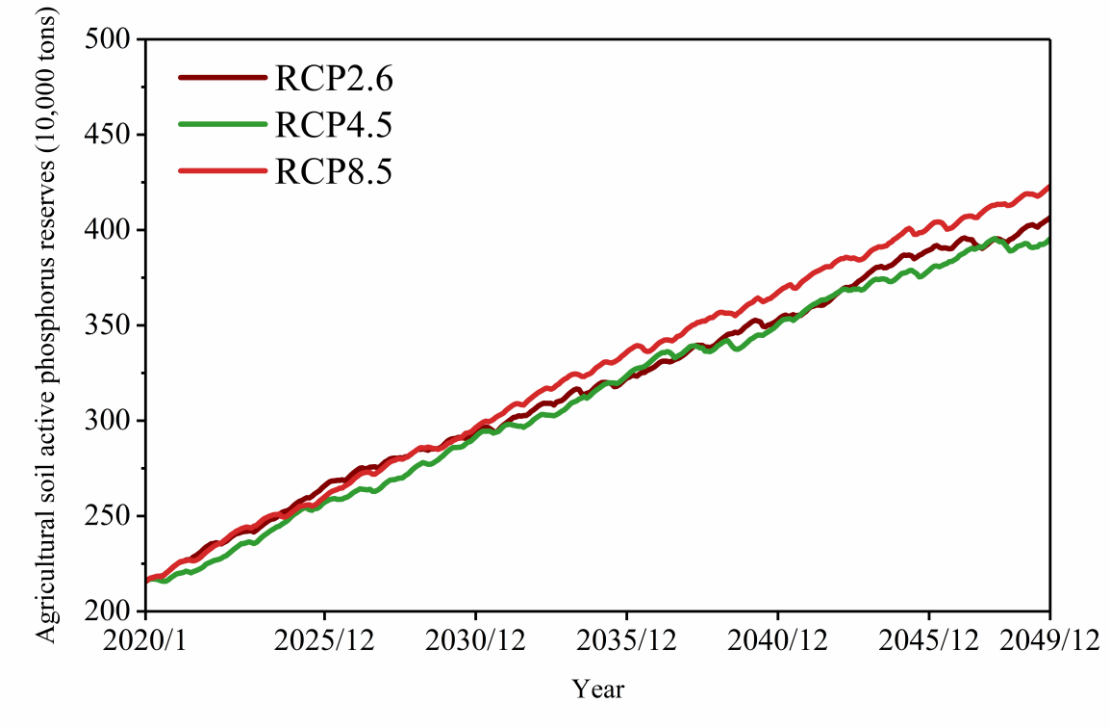
Supplementary Figure S3. Topsoil mass per m2 in Poyang Lake Basin.



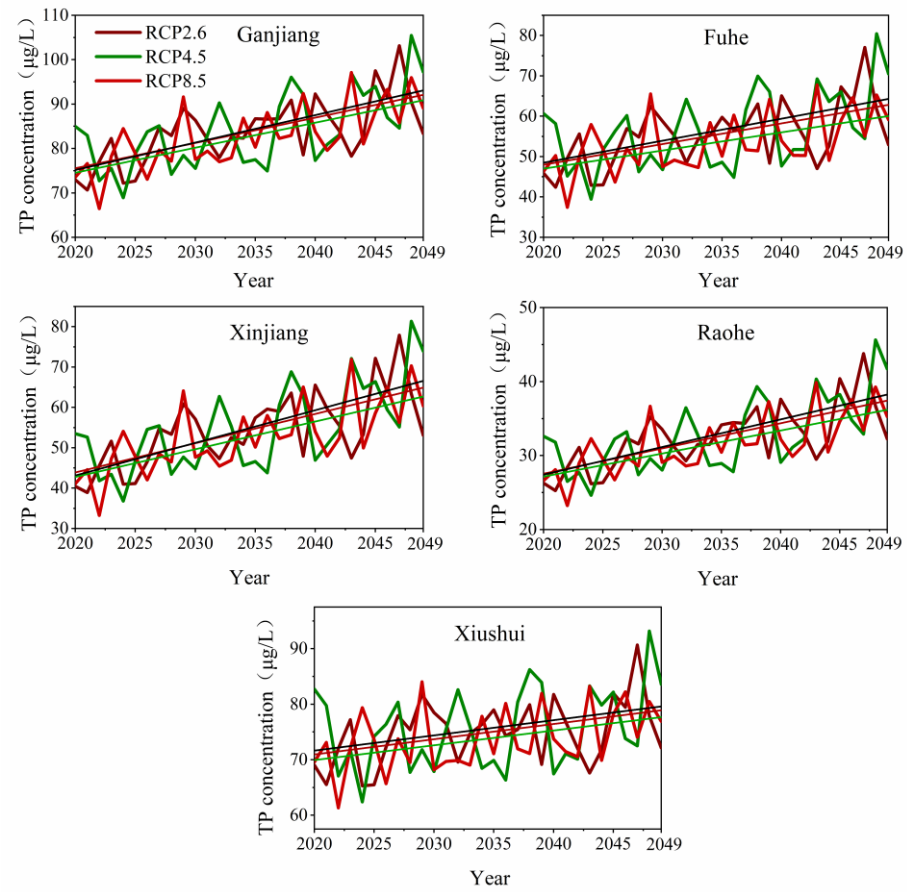
Supplementary Figure S4. China's urban domestic sewage phosphorus (point source) emission grid data set in 2018 (t).



Supplementary Figure S5. China's agricultural non-point source phosphorus emission grid data set in 2018 (t)



Supplementary Figure S6. Overall changes in agricultural soil active phosphorus inventory during 2020-2049

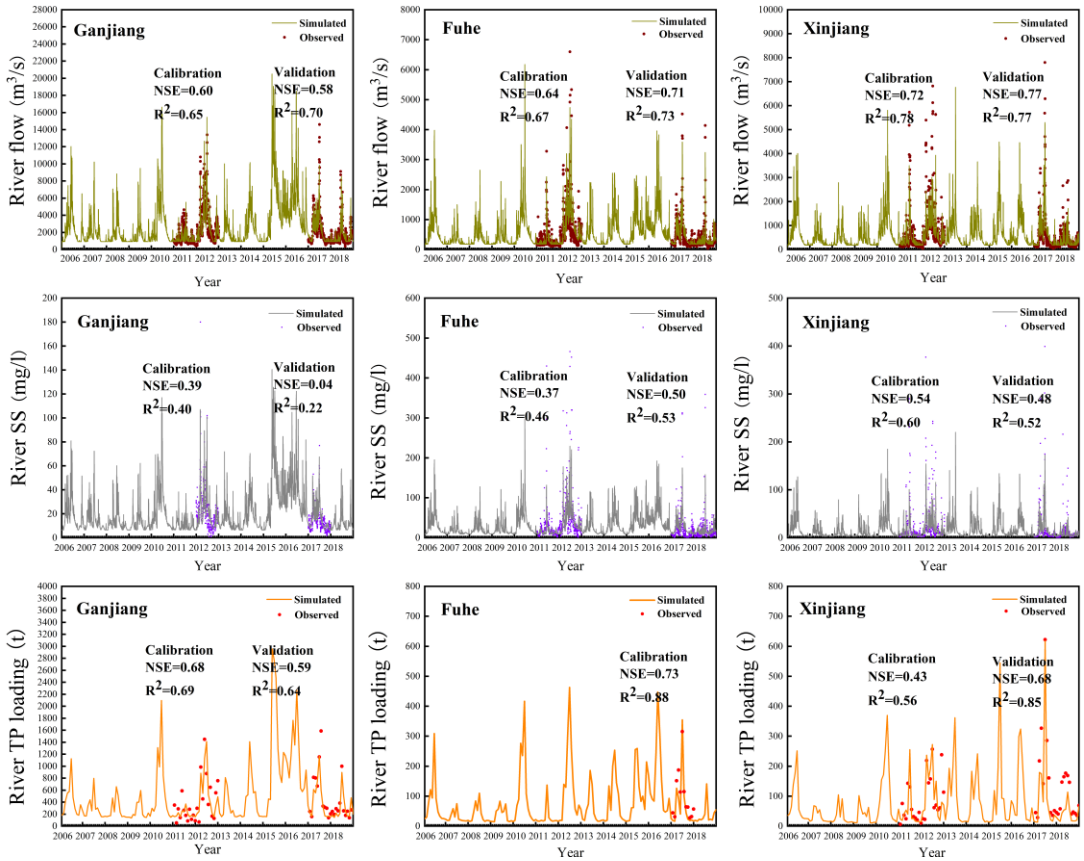


Supplementary Figure S7.Changes of TP concentration in a typical river in the RCP concentration pathway from 2020 to 2049.(The black trend line represents

RCP8.5)

Supplementary Table S2. Statistics of anthropogenic source phosphorus emission flux from each discharge unit in PLB from 2006 to 2018

Year	Livestock and poultry Breeding (t)	Rural domestic sewage (t)	IPF application (t)	straw returning to the field (t)	Urban domestic sewage (t)	Total (t)	Crop phosphorus yield (t)	The proportion of IPF application （%）	NAPI (kgP/km^2)
2006	29372	5054	121724	3554	1928	161634	41396	75.3	745
2007	28895	4980	115647	3774	1046	154342	41944	74.9	697
2008	30519	4871	112928	4235	678	153232	43639	73.7	679
2009	31968	4740	115890	4378	508	157484	45118	73.6	696
2010	33616	4701	118123	4487	751	161678	44711	73.1	725
2011	34892	4557	119814	4974	742	164979	47324	72.6	729
2012	35753	4407	122372	5238	731	168502	48310	72.6	745
2013	36607	4297	121257	5546	764	168471	49301	72.0	738
2014	37899	4189	122656	5625	794	171163	50131	71.7	750
2015	38779	4080	122012	5851	758	171481	50698	71.2	748
2016	39829	3966	121777	5845	739	172156	50473	70.7	754
2017	39121	3851	114677	6176	677	164502	51989	69.7	697
2018	37423	3741	111245	6167	672	159247	51857	69.9	665



Supplementary Figure S8. Comparisons between the observed and simulated river flow, SS, and TP loading in three typical rivers respectively during 2006–2018.